

The Science & Politics of “Climate Change”

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Why Should We Care?

- Human Well-Being
- Dominion
- Stewardship of the Natural World



Climate Change: The Basic Claim

- Global warming
- Catastrophic
- Human Induced

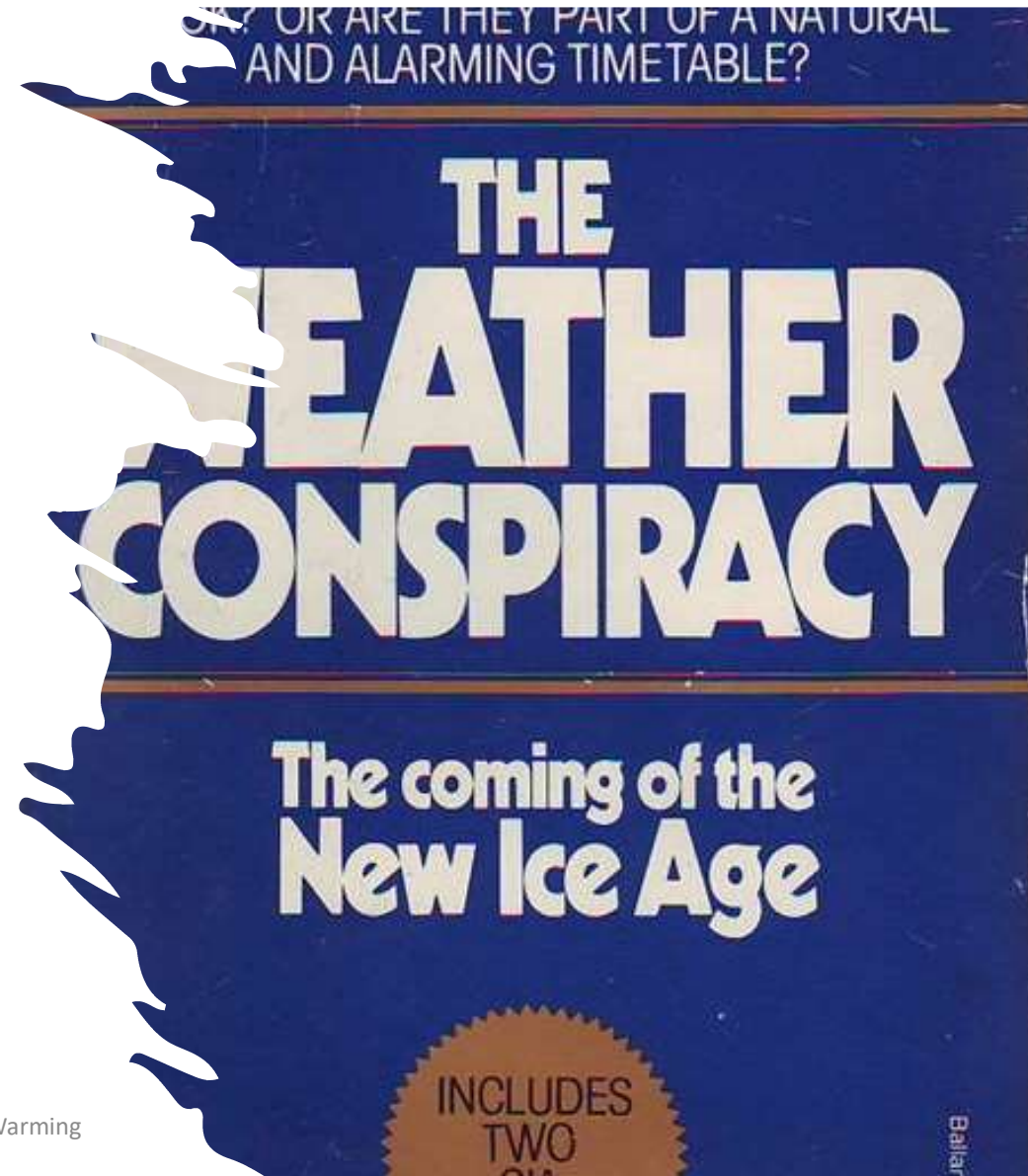


Warming or Cooling?



Global Warming

Warming or Cooling?



Global Warming

Anthropogenic Global Warming (AGW): The Basic Argument

- During the 20th century, industrialization caused a rapid rise in CO₂, a greenhouse gas.
- As a result, global temperatures have risen to unprecedented levels.
- This global warming will have catastrophic effects on the planet.

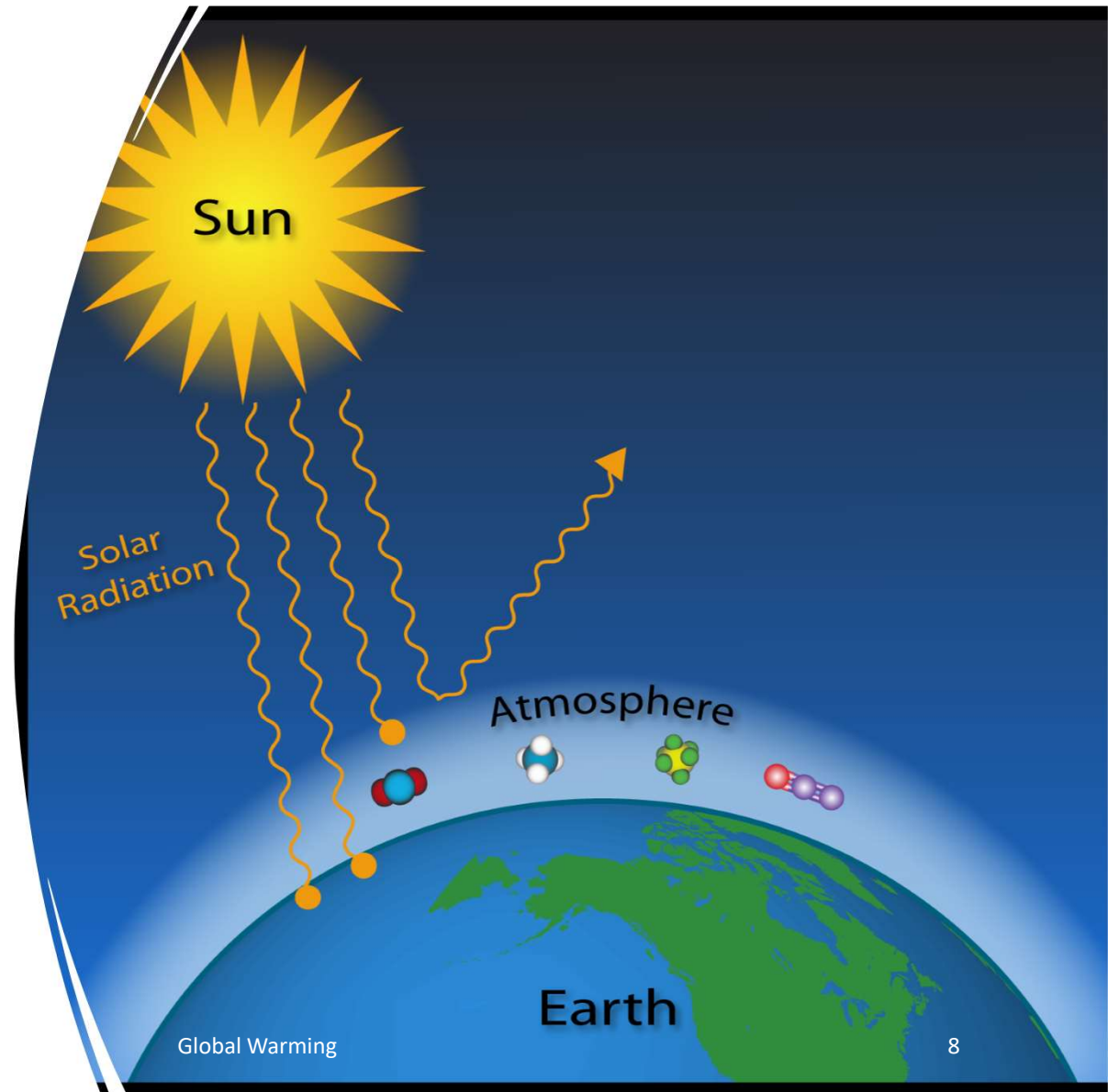
The Basic Scientific Details



What Determines Surface Temperature?

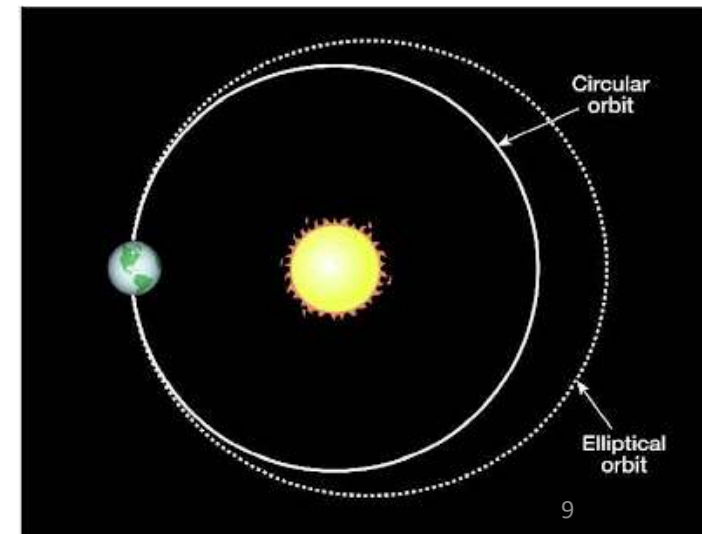
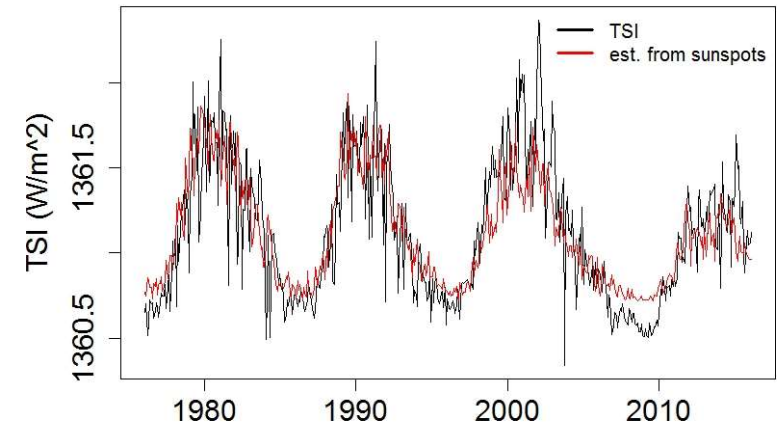
Three factors:

- (1) Intensity of sunlight
- (2) Albedo
- (3) Greenhouse effect




(1) Intensity of Sunlight

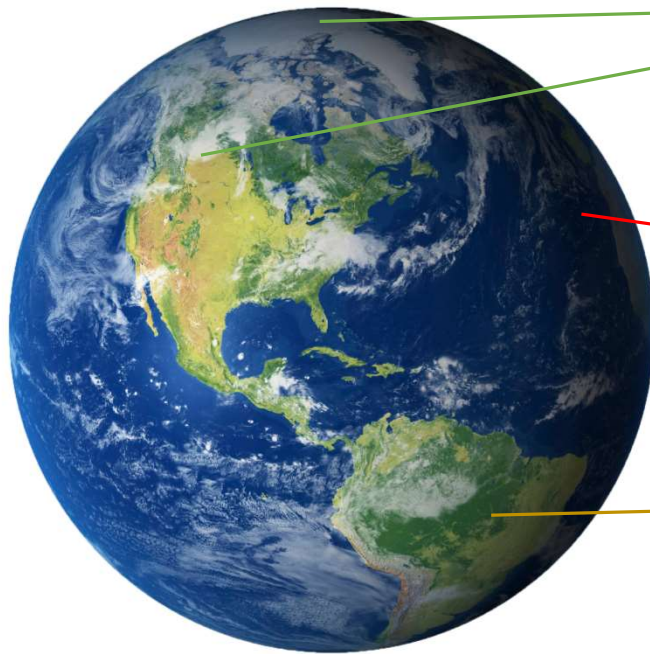
- Variation of the Sun's luminosity
- Distance from Sun
 - The closer to the Sun, the greater the intensity of sunlight.



(2) Albedo

 Albedo is the fraction of light reflected off a surface (0 to 1).

 Earth's mean albedo is about 0.30. So, it absorbs 70% of the incident sunlight.

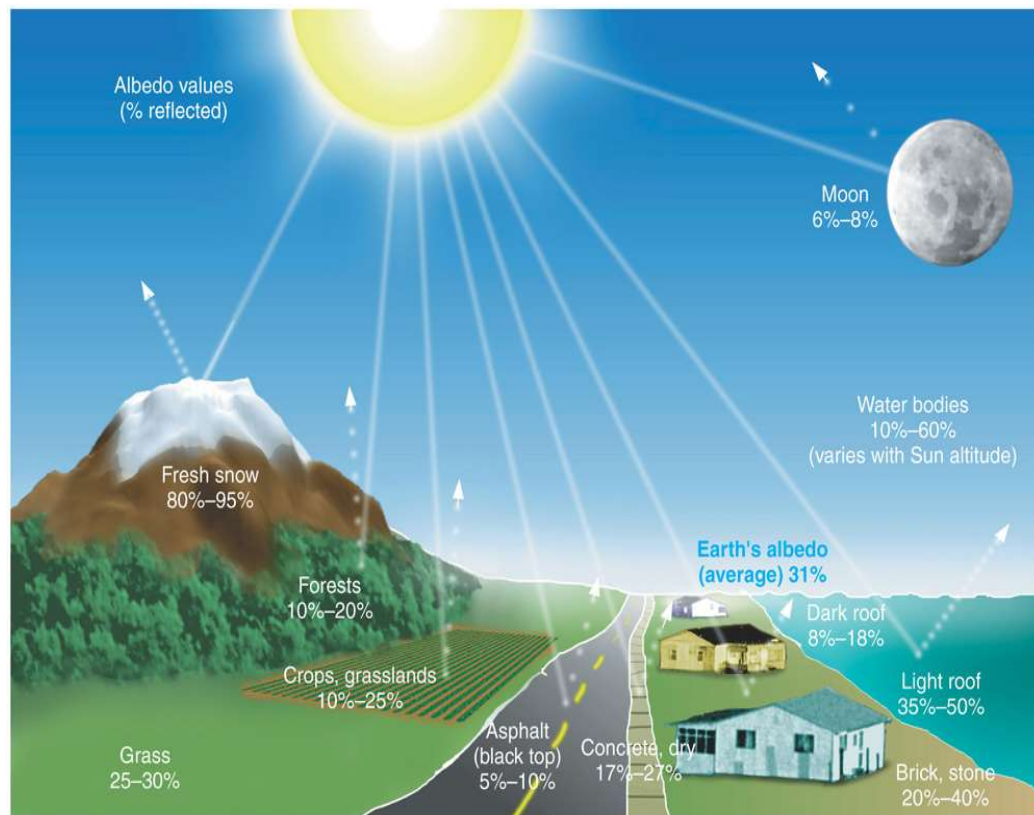


High albedo (ice, clouds)

Low albedo (oceans)

Medium albedo (land)

Clouds Have Very High Albedo



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[SAO/NASA Astrophysics Data System \(ADS\)](#)

Title: The Albedo of Clouds

Journal: Popular Astronomy, Vol. 19, 1911, p.591

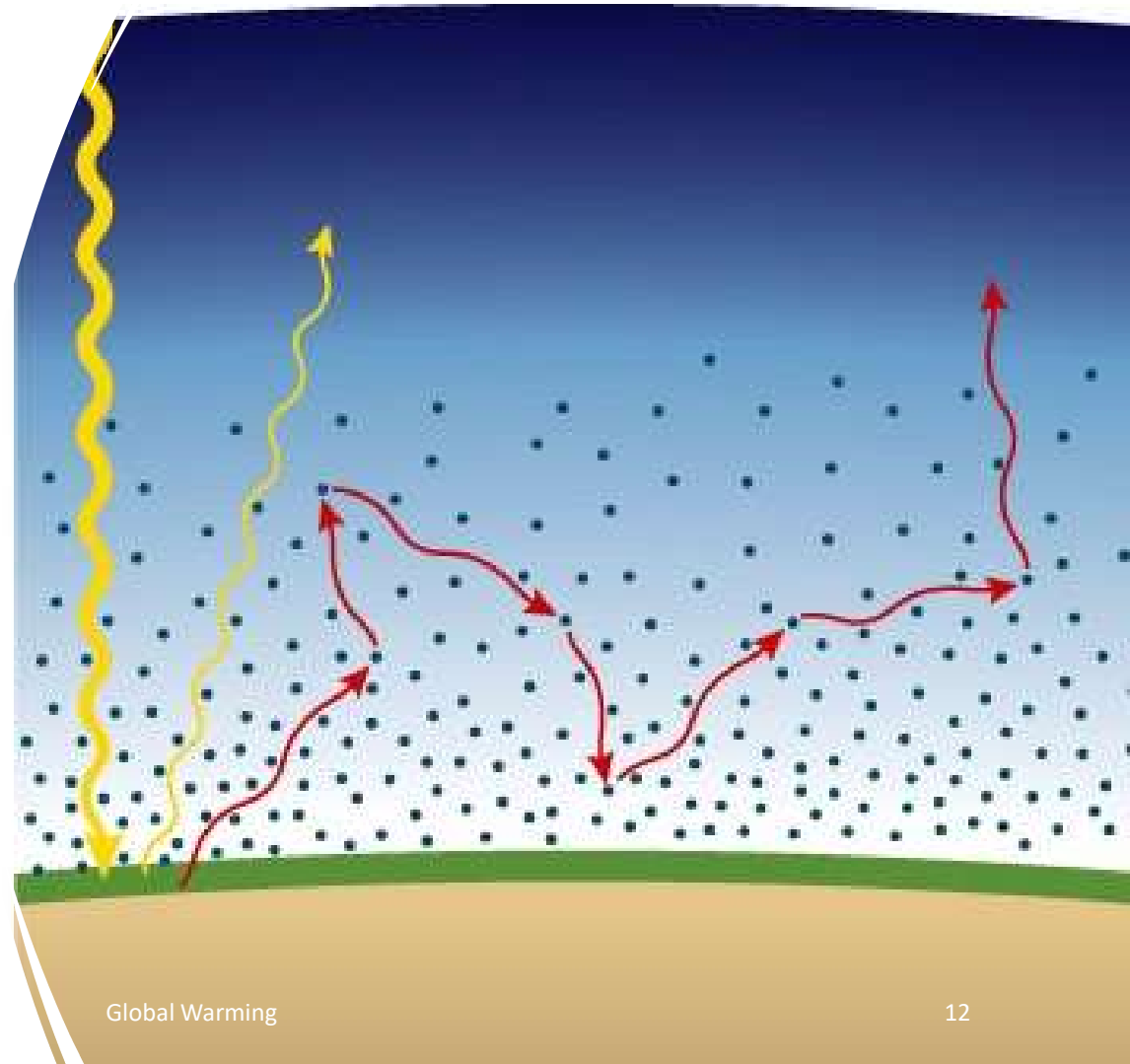
Bibliographic Code: 1911PA.....19Q.591.

[Complete bibliographic record](#)

The Albedo of Clouds.—The albedo of clouds varies between wide limits, but was formerly assumed to average about 0.75; i.e., the upper surface of the clouds was supposed to reflect about 75 percent of the incident sunlight. The albedo of white paper is 0.70; of new-fallen snow 0.78. The first attempts to measure accurately the albedo of a layer of clouds seen beneath an observer posted on the top of a mountain were those made by Abbot and Fowle on Mount Wilson in 1906, and gave an average of 0.65, but this result was later found to be doubtful, owing to errors in reduction. Within the past few months this problem, which has such important bearing upon the physics of the earth's atmosphere, has been taken up in Germany by Messrs. Stuchtey and Wegener, who made numerous measurements with a specially constructed albedometer in the course of several balloon voyages.

They found the following values, which have been corrected by eliminating the general radiation of the sky, and refer only to the proportion of direct sunlight reflected: Lower stratus clouds, 0.54; higher stratus, 0.76; cumulus, 0.67. They also measured the albedo of the earth's surface as seen from altitudes between 600 and 1650 meters. The albedo of open fields was found to average 0.15; of woods, 0.06. (*Scientific American*, July 22, 1911).

(3) The “Greenhouse Effect”

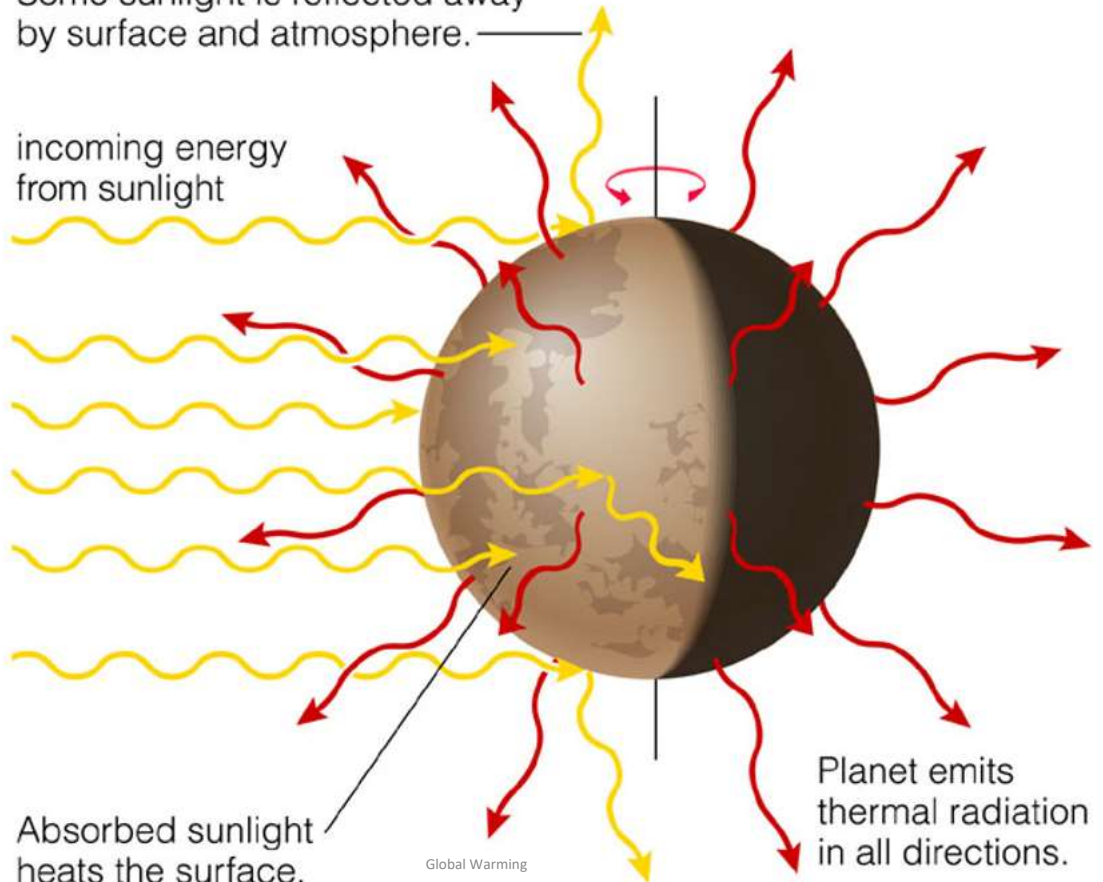


Global Energy Balance

$$\text{Incoming} - \text{Reflected} = \text{Absorbed} = \text{Emitted}$$

Some sunlight is reflected away by surface and atmosphere.

incoming energy from sunlight



Absorbed sunlight heats the surface.

Planet emits thermal radiation in all directions.

Top 3 Greenhouse Gases

1. Water – H₂O

- 0.8% of atmosphere
 - most important GHG by ~ 20X
 - condensable (clouds, ice)

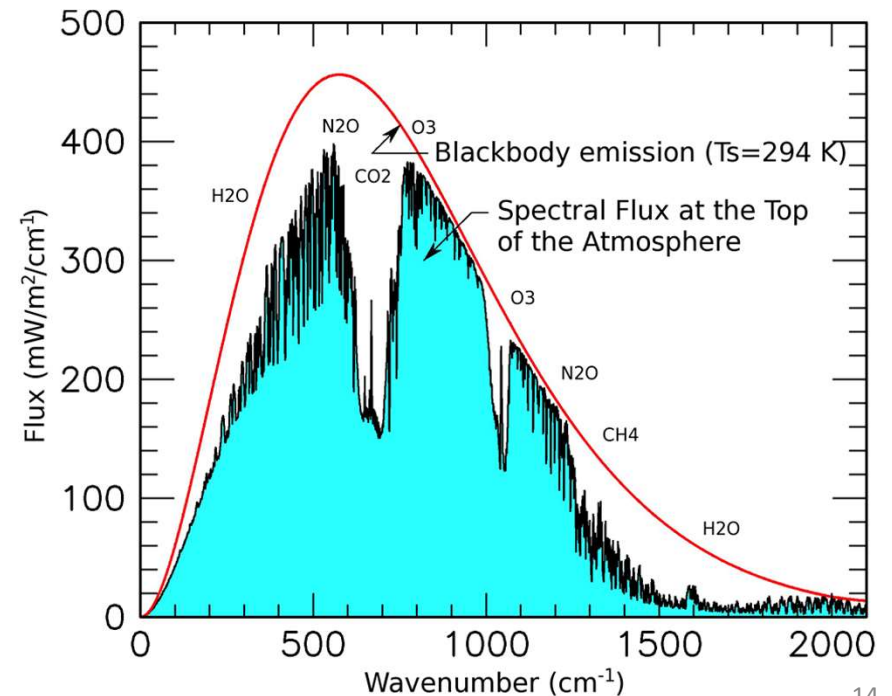
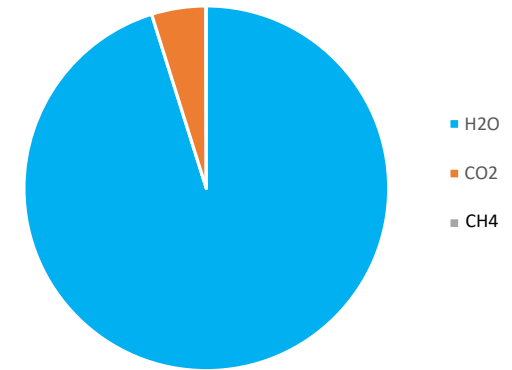
2. Carbon dioxide – CO₂

- 0.04% of atmosphere

1. Methane – CH₄

- 0.00017% of atmosphere
 - Minute
 - partially condensable

Relative Amounts of GHG's





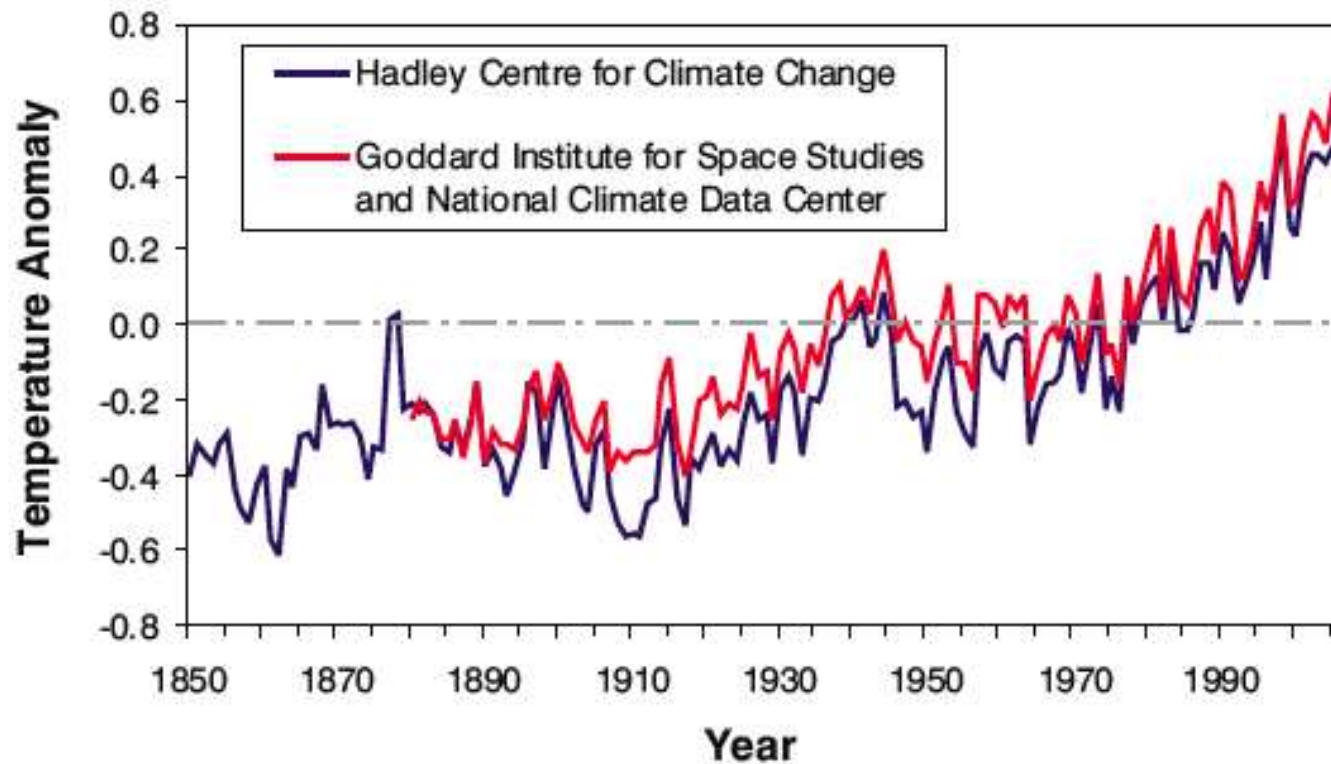
The Five Big Questions

1. Is the Earth Warming?



A Gradual Warming Trend Since 1850

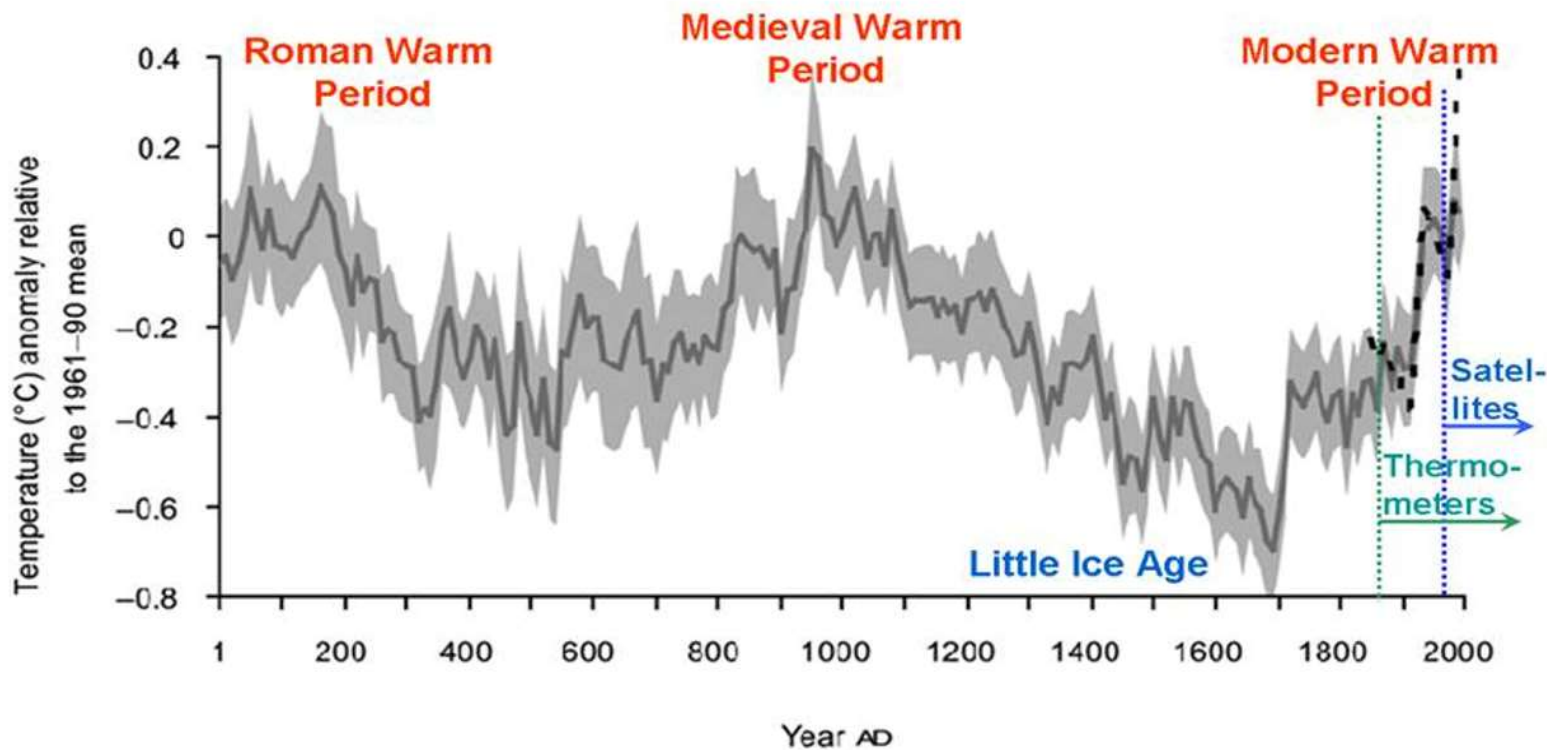
(with a decline from ~1940 to the 1970s): +0.8 Celsius.



Longer Timescales

2000 Years

2010 Northern Hemisphere Reconstruction

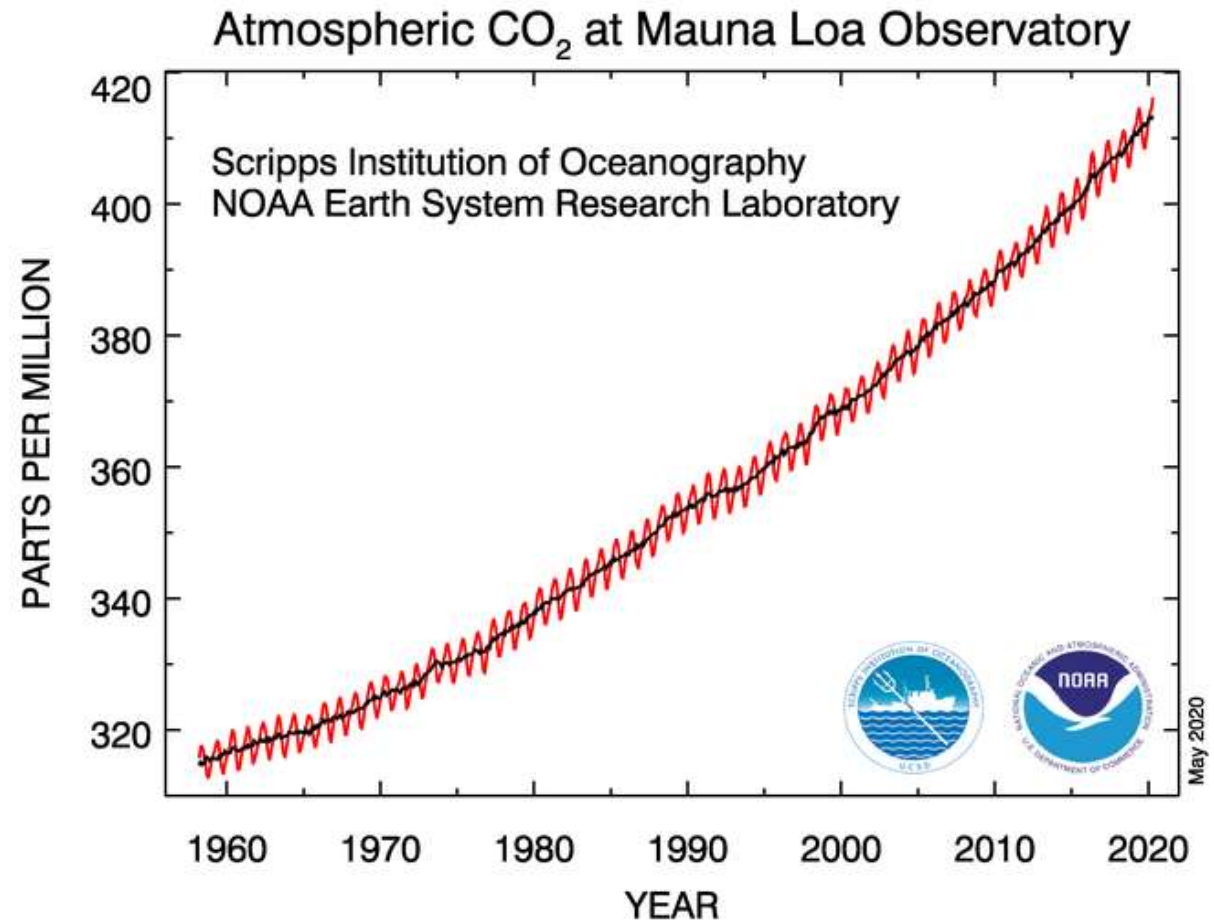


*Ljungqvist, F.C. 2010. A new reconstruction of temperature variability in the extra-tropical Northern Hemisphere during the last two millennia. *Geografiska Annaler: Physical Geography*, Vol. 92 A(3), pp. 339-351, September 2010. DOI: 10.1111/j.1468-0459.2010.00399.x

see also Loehle (2004, *Ecol. Mod.*, 171, 433)

2. Are We Causing It?

Uncontroversial:
CO2 is rising



But is CO₂ the
main *driver* of
temperature
change? No!



Glaciers
Retreating
Show ...
Warmer
Periods in
the Past

Mendenhall Glacier, Alaska



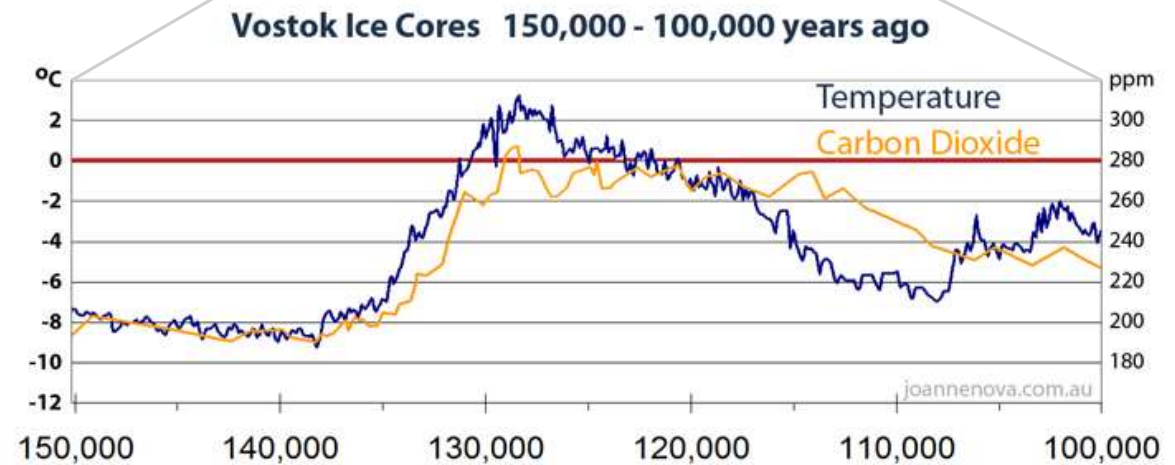
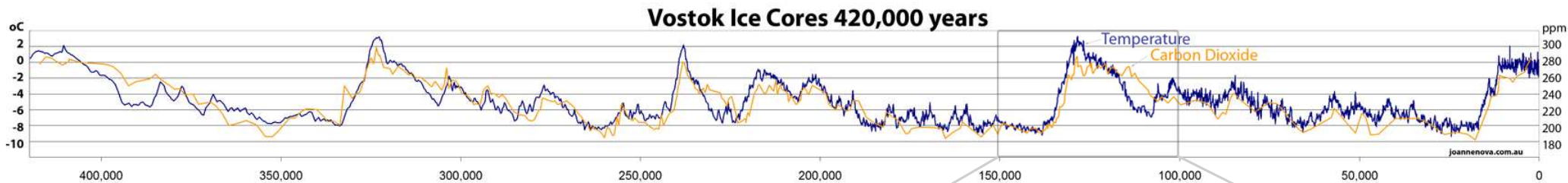
1,000-year-old tree stump
from a medieval forest.

Greenland During Medieval Warming Period



Medieval Warming ²³
Southern Greenland's Hvalsey church

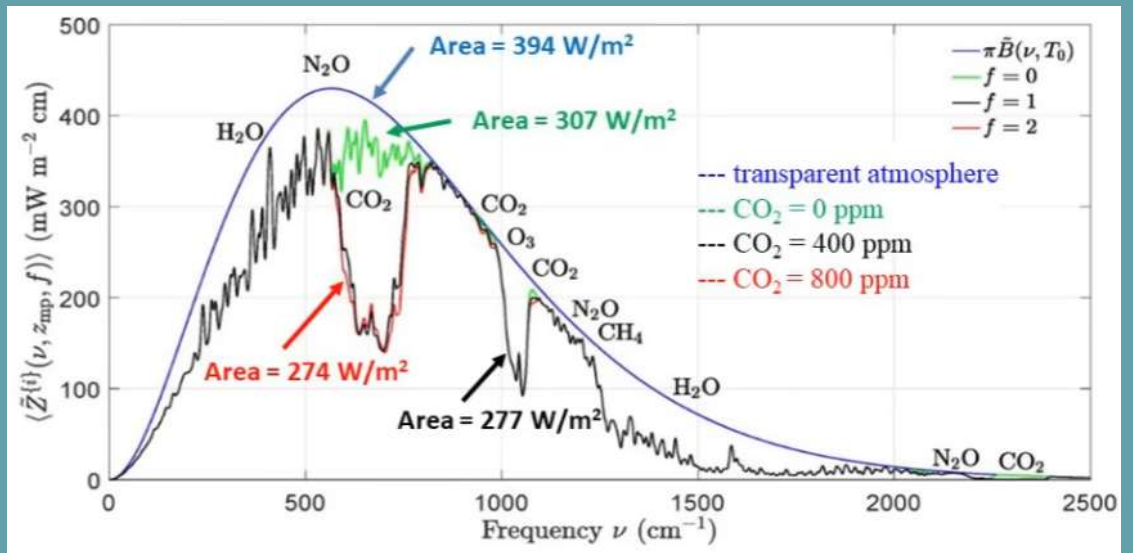
Ice Cores: CO₂ Lags Temperature by ~800 years



<http://cdiac.ornl.gov/ftp/trends/temp/vostok/vostok.1999.temp.dat> and <http://cdiac.ornl.gov/ftp/trends/co2/vostok.icecore.co2>
But both these links are now defunct.

CO₂ is mostly **impotent** in driving temperatures any further

- CO₂ effect very pronounced going from 0 to 400 ppm
- But diminishing returns beyond it (< 1 C for doubling)



Credit: Dr. W. Happer, Princeton U.